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(71) Applicant(s)
Samsung Electronics Co., Ltd.
(Incorporated in the Republic of Korea)
416 Maetan-dong, Paldal-gu, Suwon-city,
Kyungki-do, Republic of Korea

(72) Inventor(s)
Ho-Seong Lee

(74) Agent and/or Address for Service
Appleyard Lees
15 Clare Road, HALIFAX, West Yorkshire, HX1 2HY,
United Kingdom

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(54) Abstract Title

Maintaining the average screen light level for a liquid crystal display

(57) An apparatus for maintaining the average light level of a screen for a ferroelectric liquid crystal display including an average light level detector (100a) for detecting the average light level of an input signal, using a predetermined pixel value of the input signal, a system controller (102a) for providing a predetermined reference average light level, and a screen light adjuster (104a) adjusting the light of a screen so that the difference between the average light level of the input signal and the reference average light level is reduced, and keeping the average light level of the screen uniform. Various embodiments are described for determining the average light level of the input signal, and for controlling the screen.

FIG. 1A

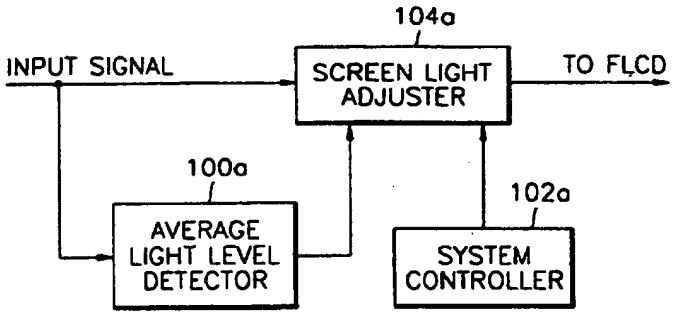

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FIG. 1A

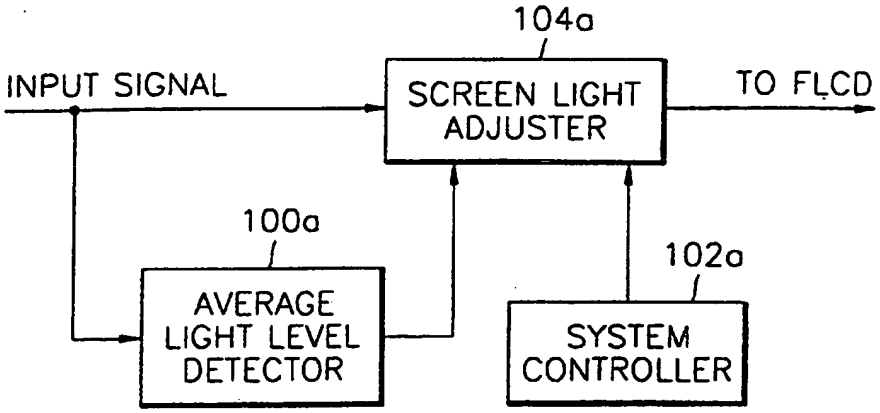

104a
INPUT SIGNAL
SCREEN LIGHT ADJUSTER
TO FLCD
100a
AVERAGE LIGHT LEVEL DETECTOR
102a
SYSTEM CONTROLLER

FIG. 1B

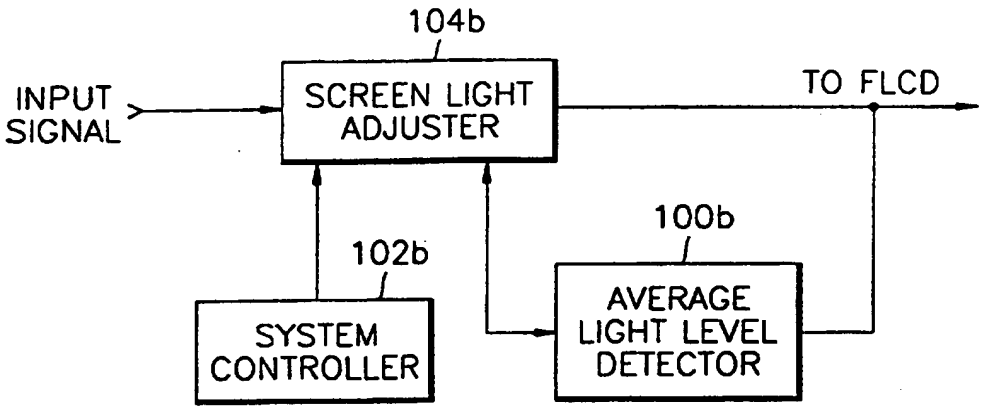

104b
INPUT SIGNAL
SCREEN LIGHT ADJUSTER
TO FLCD
100b
AVERAGE LIGHT LEVEL DETECTOR
102b
SYSTEM CONTROLLER

FIG. 2A

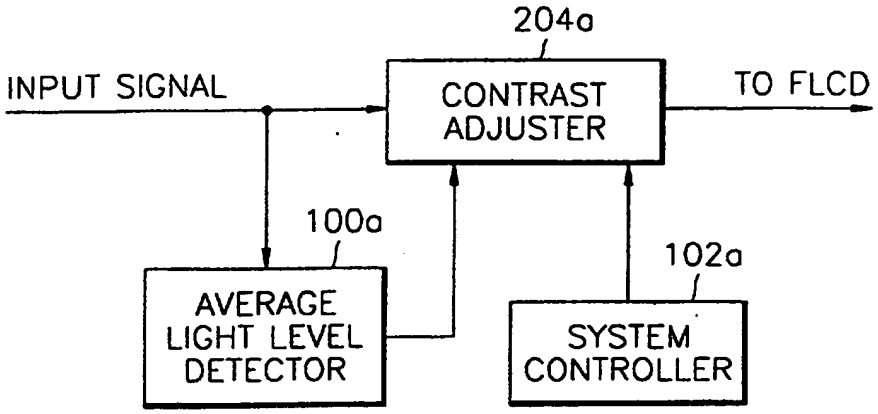


FIG. 2B

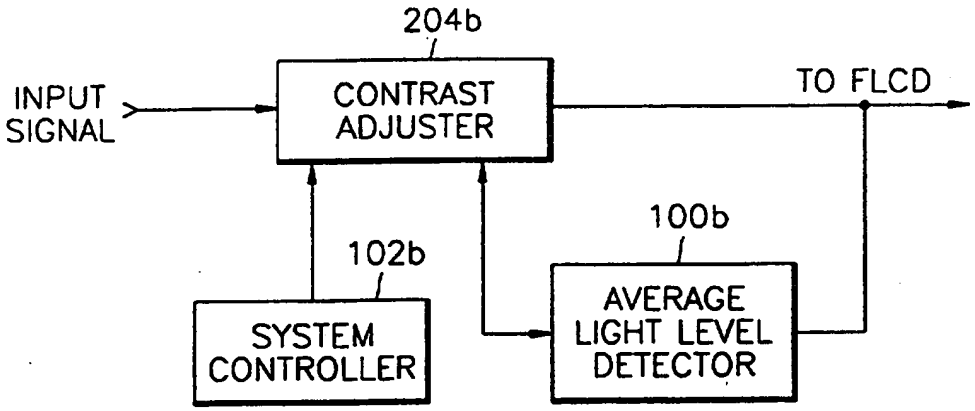


FIG. 3

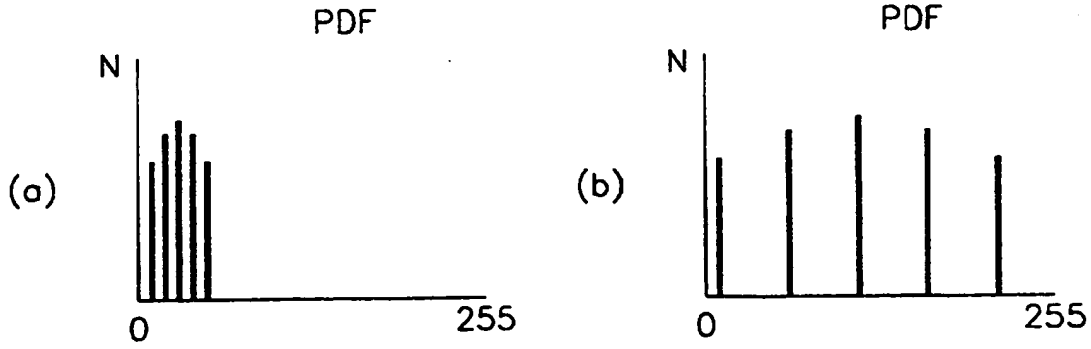


FIG. 4A

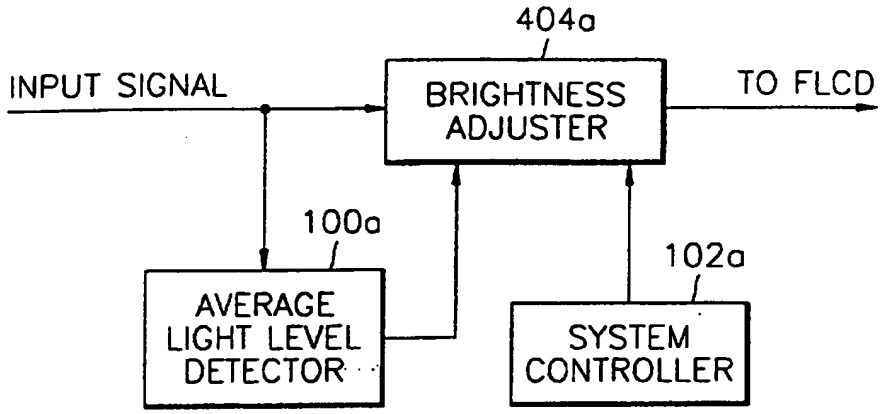


FIG. 4B

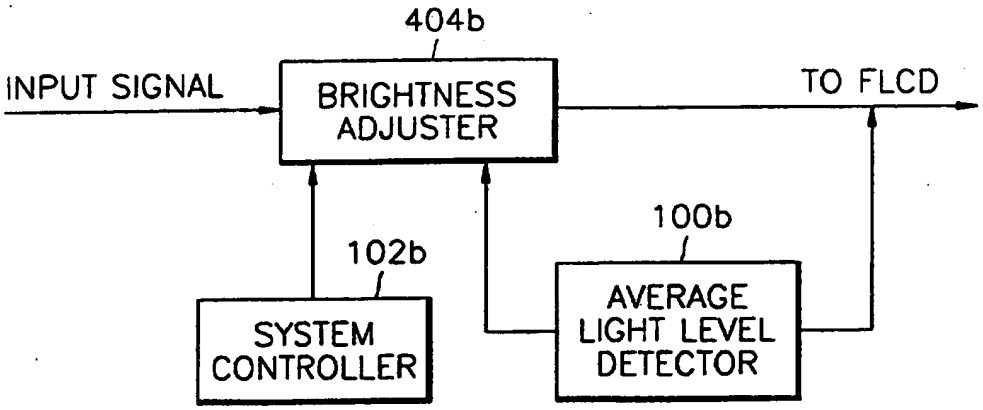


FIG. 5

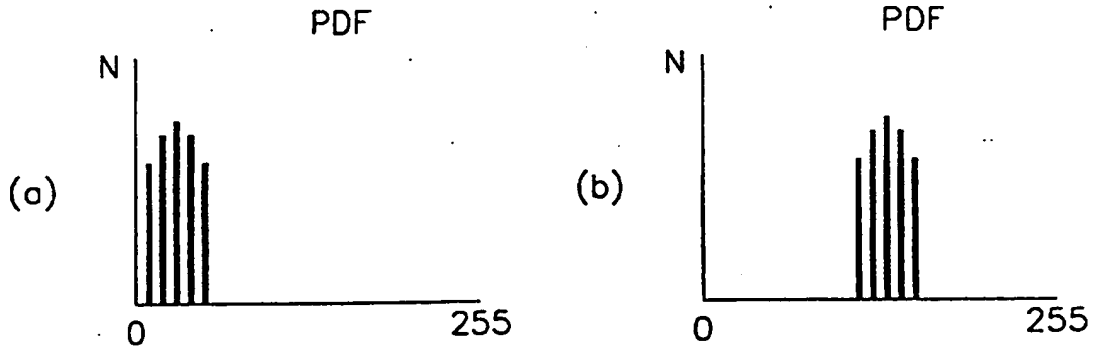


FIG. 6A

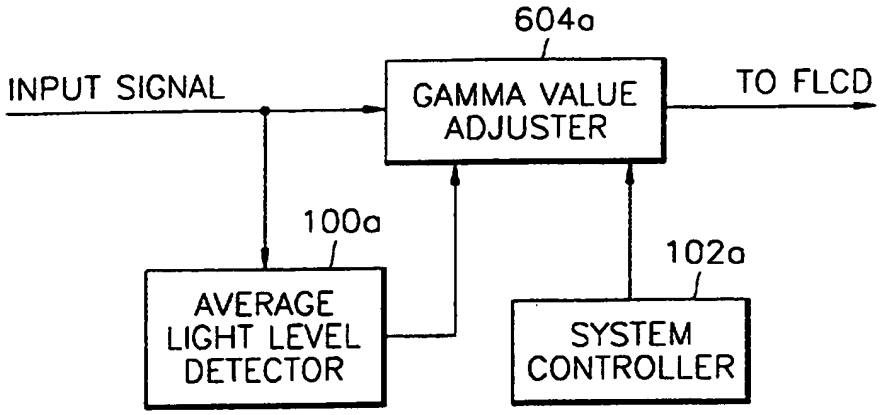


FIG. 6B

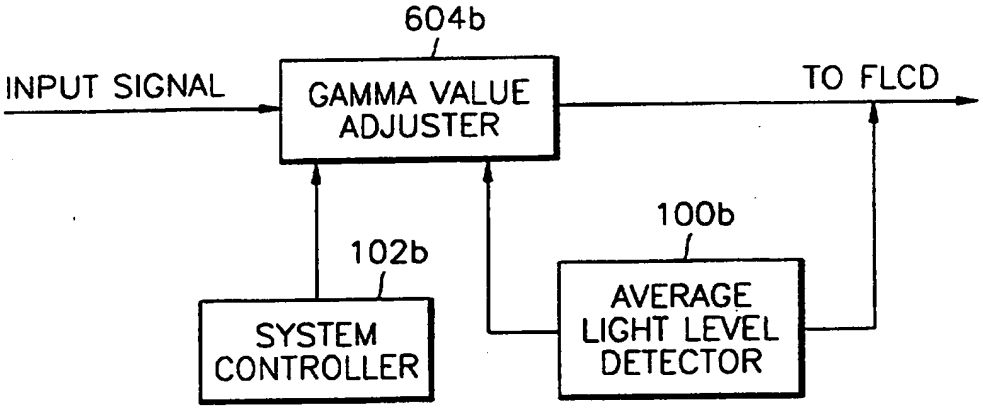


FIG. 7

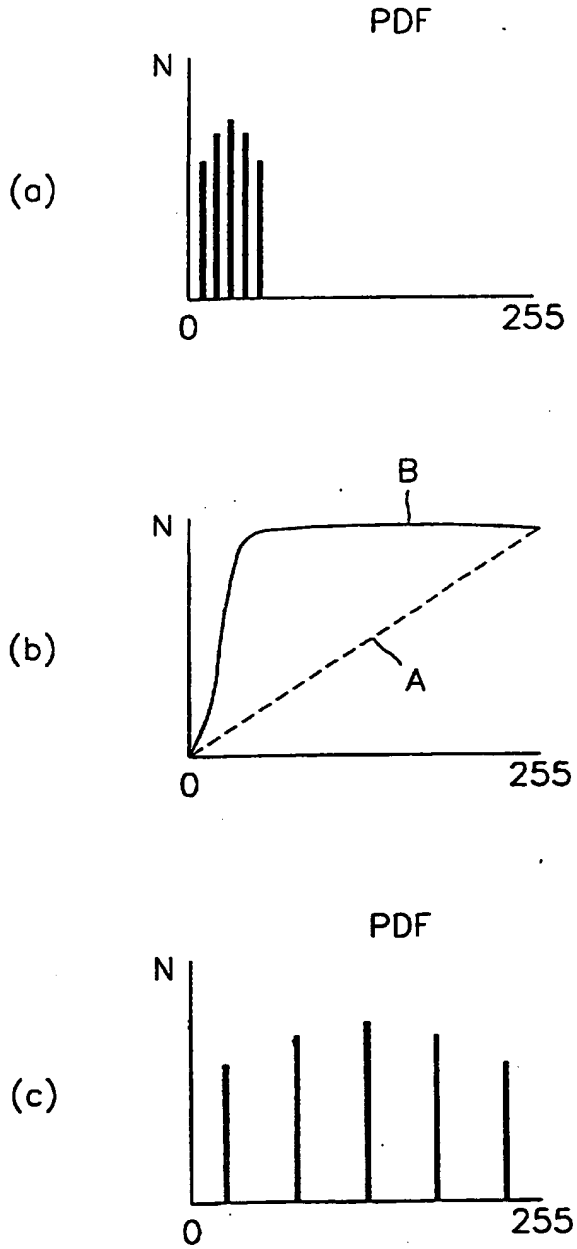


FIG. 8A

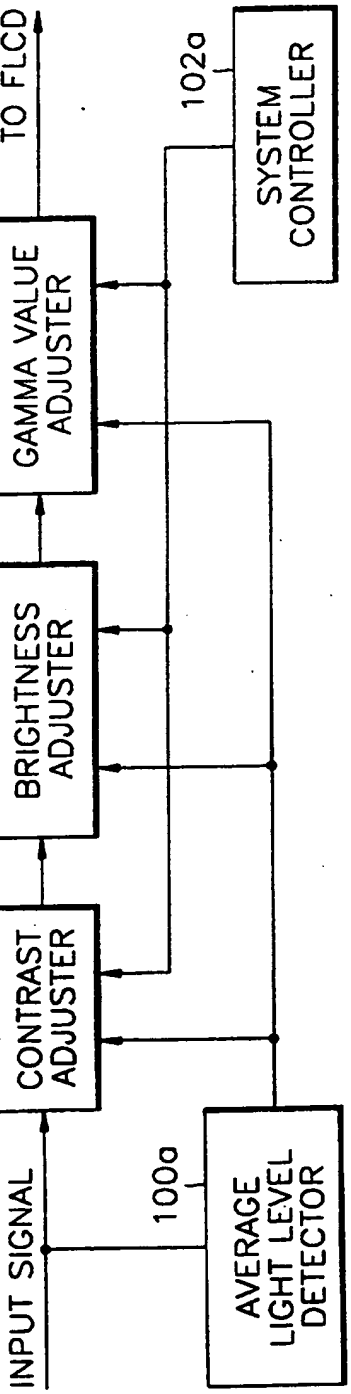
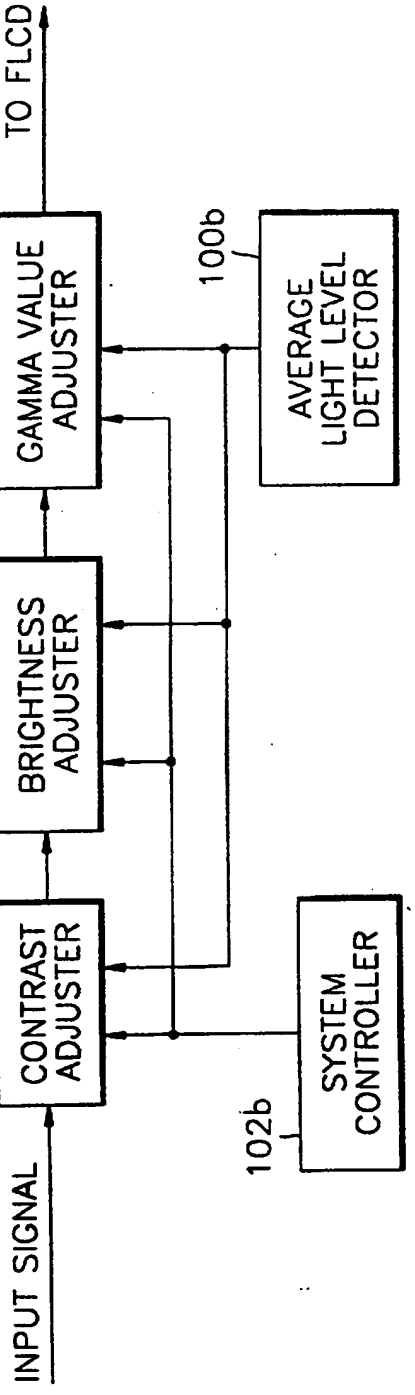


FIG. 8B



APPARATUS FOR MAINTAINING AVERAGE SCREEN LIGHT LEVEL FOR FERROELECTRIC LIQUID CRYSTAL DISPLAY

The present invention relates to a ferroelectric liquid crystal display (LCD), and more particularly, to an apparatus for maintaining the average screen light level for a ferroelectric liquid crystal display (LCD).

It is an aim of the present invention to provide an apparatus for maintaining the average screen light level for a ferroelectric LCD so that the difference between the average light level of an input signal and a predetermined reference average light level is reduced.

According to one aspect of the present invention there is provided an apparatus for maintaining the average light level of a screen for a ferroelectric liquid crystal display (LCD), comprising an average light level detector for detecting the average light level of an input signal, using a predetermined pixel value of the input signal, a system controller for providing a predetermined reference average light level, and a screen light adjuster for receiving a reference average light level provided by the average light level of the input signal output from the average light level detector and the reference average light level provided by the system controller, adjusting the light of a screen so that the difference between the average light level of the input signal and the reference average light level is reduced, and keeping the average light level of the screen uniform.

The system controller provides various reference average light levels corresponding to predetermined pixel values.

Preferably, the average light level detector determines the average light level by summing the pixel values of the input signals contained in one frame, by summing arbitrary upper bits of each pixel of the input signals contained in one frame, by summing the input signals of one frame, selecting an arbitrary upper bit value from the result, and determining the selected upper bit value to be the average light level, by summing arbitrary upper bits of each line of the input signals contained in one frame, by summing pixel values of arbitrary regions of the input signals of one frame, or by selecting two or more steps among the steps of determining the average light level by summing all the pixel values of the input signals of one frame, determining the average light level by summing arbitrary upper bits of each pixel of the input signals contained in one frame, summing the input signals of one frame and determining the average light level by selecting arbitrary upper bits among the added result, determining the average light level by summing arbitrary upper bits each line of the input signals contained in one frame, and determining the average light level by summing pixel values in arbitrary regions of the input signals contained in one frame and combining the selected steps.

The screen light adjuster adjusts the contrast, the brightness, and the gamma value of the input signal or selects two or more steps among the steps of adjusting the contrast of the input signal, adjusting the brightness of

the input signal, and adjusting the gamma value of the input signal and combines the selected steps.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figures 1A and 1B are block diagrams each of which shows the structure of an apparatus for maintaining the average screen light level for a ferroelectric liquid crystal display (LCD) according to a first embodiment of the present invention;

Figures 2A and 2B are block diagrams each of which shows the structure of the screen light adjusters of Figures 1A and 1B respectively according to a first embodiment;

Figure 3 shows the distribution of the average light level and the adjusted average light level of the input signal of Figure 2;

Figures 4A and 4B are block diagrams each of which shows the structure of the screen light adjusters of Figures 1A and 1B respectively according to a second embodiment;

Figure 5 shows the distribution of the average light level and the adjusted average light level of the input signal of Figures 4A and 4B;

Figures 6A and 6B are block diagrams each of which shows the structure of the screen light adjuster of Figures 1A and 1B respectively according to a third embodiment;

Figure 7 shows the distribution of the average light level and the adjusted average light level of the input signal of Figures 6A and 6B; and

Figures 8A and 8B are block diagrams each of which shows the structure of the screen light adjusters of Figures 1A and 1B according to a fourth embodiment.

Figures 1A and 1B are block diagrams each of which shows the structure of an apparatus for maintaining the average screen light level for a ferroelectric liquid crystal display (LCD) according to a first embodiment of the present invention.

The apparatus shown in Figures 1A or 1B consists of average light level detectors 100a and 100b, system controllers 102a and 102b, and screen light adjusters 104a and 104b.

The average light level detectors 100a and 100b detect the average light levels of input signals using predetermined pixel values of the input signals. The system controllers 102a and 102b provide predetermined reference average light levels.

The screen light adjusters 104a and 104b receive the average light levels of the input signals output from the average light level detectors 100a and 100b and the

reference average light levels provided by the system controllers 102a and 102b, and control the light of the screen so that the difference between the average light levels of the input signals and the reference average light levels is reduced, thus maintaining the average light of the screen. Preferably, the screen light level is adjusted by various methods to be described hereinafter. A method for adjusting the contrast of an input signal, a method for adjusting the brightness of an input signal, a method for correcting the gamma value of an input signal, and a method combining two or more of the above methods will now be described as a preferred embodiment.

The system controllers 102a and 102b output the optimal average screen light level designated by a system designer wherein how predetermined pixel values are used by the average light detectors 100a and 100b is previously estimated. In other words, the system controllers 102a and 102b, according to the present invention, provide various reference average light levels corresponding to the cases described by Equations 1 through 5.

First, the average light level detectors 100a and 100b detect a value obtained by adding all pixel values input signals carry in one frame to each other as an average light level. Here, if input image signals are referred to as X[i, j] with the x axis coordinate value as i, and the y axis coordinate value as j, the average light data (M) can be obtained by using Equation 1.

$$M = \sum_{j=0}^{ysize} \sum_{i=0}^{xsize} X[i, j] \quad \ldots (1)$$

The screen light adjusters 104a and 104b receive and compare the average light levels output from the average light level detectors 100a and 100b with the reference average light levels provided by the system controllers 102a and 102b and control the average screen light level with respect to input signals so that the difference between the average light levels of the input signals and the reference average light levels is reduced.

A method for adjusting the average light level of the input signals will now be described through various embodiments.

Other methods in which the average light level detectors 100a and 100b do not add all pixel values input signals carry in one frame to each other as in Equation 1 will be described with reference to Equations 2 through 5.

Second, the average light level detectors 100a and 100b detect a value obtained by adding arbitrary upper bits of each pixel input signals carry in one frame to each other as the average light level. Here, when the signal represented to be arbitrary upper bits (m) in all pixels of the input signals is referred to as MSB(X[i, j], m), the average light data (M) can be obtained by using Equation 2.

$$M = \sum_{j=0}^{ysize} \sum_{i=0}^{xsize} MSB(X[i,j],m) \quad \ldots(2)$$

Third, in case the average light level detectors 100a and 100b add the input signals of one frame to each other, selecting arbitrary upper bit values among the added results, thereby detecting the average upper bit value, the average light data (M) can be obtained by using Equation 3.

$$M = MSB \sum_{j=0}^{ysize} \sum_{i=0}^{xsize} (X[i,j],m) \quad \ldots(3)$$

Fourth, the average light level detectors 100a and 100b detect a value obtained by adding arbitrary upper bits of each line input signals carry in one frame to each other as the average light level. Here, the average light data can be obtained by using Equation 4.

$$M = MSB\left(\sum_{j=0}^{ysize} MSB\left(\sum_{i=0}^{xsize} (X[i,j],m1),m2\right)\right) \quad \ldots(4)$$

Fifth, the average light level detectors 100a and 100b detect a value obtained by adding pixel values in arbitrary regions input signals carry in one frame to each

other as the average light level. Here, the average light data can be obtained by using Equation 5.

$$M = \sum_{j=y1}^{y2} \sum_{i=x1}^{x2} X[i, j] \quad \ldots (5)$$

Finally, the average light level detectors 100a and 100b can also detect the average light level by combining two or more of the preceding five steps.

Figures 2A and 2B are block diagrams each of which shows the structure of the screen light adjuster of Figures 1A and 1B respectively according to a first embodiment, wherein the screen light level is adjusted by a contrast adjuster.

The apparatus shown in Figure 2A or 2B includes average light level detectors 100a and 100b, system controllers 102a and 102b, and contrast adjusters 204a and 204b.

Figure 3A shows the distribution of the average light level of the input signal detected by the average light level detector 100a. When the input signal having the average light corresponding to the probability density function shown in Figure 3A is input to the contrast adjuster 204a, the contrast adjuster 204a keeps the average light of the input signal uniform using a contrast adjustment control signal for reducing the difference

between the reference average light level provided by the system controller 102a and the average light level of the input signal.

Figure 3B shows the distribution of the average light of the input signal with its contrast adjusted. Assuming that the average light level of the input signal in the distribution shown in Figure 3A is 10 and the reference average light level provided by the system controller 102a is 30, the contrast adjuster 204a keeps the average light level of the input signal uniform by increasing the contrast so that the average light level of the input signal becomes equal to the reference light level, which is 30.

Figures 4A and 4B are block diagrams each of which shows the structure of the screen light adjuster of Figures 1A and 1B respectively according to a second embodiment, in which the average light of the screen is corrected by adjusting a brightness level. The apparatus shown in Figure 4A or 4B includes average light level detectors 100a and 100b, system controllers 102a and 102b, and brightness adjusters 404a and 404b.

Figure 5A shows the distribution of the average light of the input signal detected by the average light level detector 100b. When the input signal having the average light level corresponding to the probability density function shown in Figure 5A is input to the brightness adjuster 404b, the brightness adjuster 404b keeps the average brightness of the input signal uniform by utilizing a brightness adjustment control signal for reducing the difference between the reference average

light level provided by the system controller 102b and the average light level of the input signal.

Figure 5B shows the distribution of the average light of the input signal with its brightness adjusted. Assuming that the average light level of the input signal in the distribution shown in Figure 5A is 10 and the reference average light level provided by the system controller 102b is 30, the brightness adjuster 404b keeps the average light level of the input signal uniform by increasing the brightness level so that the average light level of the input signal becomes equal to the reference light level, which is 30.

Figures 6A and 6B are block diagrams each of which shows the structure of the screen light adjuster of Figures 1A and 1B respectively according to a third embodiment wherein the average light of the screen is corrected by adjusting a gamma value. The apparatus shown in Figure 6A or 6B includes average light level detectors 100a and 100b, system controllers 102a and 102b, and gamma value adjusters 604a and 604b.

Figure 7A shows the distribution of the average light level of the input signal detected by the average light level detector 100a. Figure 7B shows a gamma curve. The dotted line A in Figure 7B shows the gamma value of the distribution shown in Figure 7A. When the input signal having the average light level corresponding to the probability density function shown in Figure 7A is input to the gamma value adjuster 604a, the gamma value adjuster 604a keeps the average light of the input signal having the distribution shown in Figure 7C uniform with the use

of a gamma value adjustment control signal for reducing the difference between the reference average light level provided by the system controller 102a and the average light level of the input signal, consequently creating the gamma curve shown in Figure 7B.

Figures 8A and 8B are block diagrams each of which shows the structure of the screen light adjuster of Figures 1A and 1B according to a fourth embodiment. Here, the average light of the screen is adjusted by implementing two or more blocks among the contrast adjusters 204a and 204b for adjusting the contrast of the input signal, the brightness adjusters 404a and 404b for adjusting the brightness of the input signal, and the gamma value adjusters 604a and 604b for adjusting the gamma value of the input signal, thereby combining the selected blocks together.

In the cases described above, the input screen light level is adjusted so as to reduce the difference between the average light levels detected from the input signals and the reference average light levels provided by the system controllers 102a and 102b.

It is possible to control the screen light level by reducing the difference between the average screen light level detected from the input signal and the reference average light level, thereby keeping the screen light level uniform. Accordingly, the present invention can provide comfortable operating circumstances to a user.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to

this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An apparatus for maintaining the average light level of a screen for a ferroelectric liquid crystal display, comprising:

an average light level detector for detecting the average light level of an input signal, using a predetermined pixel value of the input signal;

a system controller for providing a predetermined reference average light level; and

a screen light adjuster for receiving a reference average light level provided by the average light level of the input signal output from the average light level detector and the reference average light level provided by the system controller, adjusting the light of a screen so that the difference between the average light level of the input signal and the reference average light level is reduced, and keeping the average light level of the screen uniform.

2. The apparatus of claim 1, wherein the system controller provides a reference average light level corresponding to predetermined pixel values.

3. The apparatus of claim 1 or 2, wherein the average light level detector determines the average light level by summing the pixel values of the input signals contained in one-frame.

4. The apparatus of claim 1 or 2, wherein the average light level detector determines the average light level by summing arbitrary upper bits of each pixel of the input signals contained in one frame.

5. The apparatus of claim 1 or 2, wherein the average light level detector sums the input signals of one frame, selects an arbitrary upper bit value from the result, and determines the selected upper bit value to be the average light level.

6. The apparatus of claim 1 or 2, wherein the average light level detector determines the average light level by summing arbitrary upper bits of each line of the input signals contained in one frame.

7. The apparatus of claim 1 or 2, wherein the average light level detector determines the average light level by summing pixel values of arbitrary regions of the input signals of one frame.

8. The apparatus of claim 1 or 2, wherein the average light level detector selects two or more steps among the steps of determining the average light level by summing all the pixel values of the input signals of one frame, determining the average light level by summing arbitrary upper bits of each pixel of the input signals contained in one frame, summing the input signals of one frame and determining the average light level by selecting arbitrary upper bits among the added result, determining the average light level by summing arbitrary upper bits each line of the input signals contained in one frame, and determining the average light level by summing pixel values in

arbitrary regions of the input signals contained in one frame, and combines the selected steps.

9. The apparatus of any of claims 1 to 8, wherein the screen light adjuster adjusts the contrast of the input signal.

10. The apparatus of any of claims 1 to 8, wherein the screen light adjuster adjusts the brightness of the input signal.

11. The apparatus of any of claims 1 to 8, wherein the screen light adjuster adjusts the gamma value of the input signal.

12. The apparatus of any of claims 1 to 8, wherein the screen light adjuster selects two or more steps among the steps of adjusting the contrast of the input signal, adjusting the brightness of the input signal, and adjusting the gamma value of the input signal and combines the selected steps.

13. An apparatus for maintaining the average light level of a screen for a ferroelectric liquid crystal display substantially as hereinbefore described with reference to the accompanying drawings.

14. An apparatus for maintaining the average light level of a screen for a ferroelectric liquid crystal display substantially as hereinbefore described with reference to any of Figures 1A, 1B, 2A, 2B, 4A, 4B, 6A, 6B, 8A or 8B of the accompanying drawings.

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Application No: GB 0024228.9 16 **Examiner:** Geoffrey Pitchman
Claims searched: 1 to 14 **Date of search:** 3 May 2001

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): G5C (CHBH)

Int Cl (Ed.7): G09G 3/36 H04N 5/20

Other: ONLINE: EPODOC WPI JAPIO INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP 0374372 A2	(MITSUBISHI)-see abstract	
A	WO 97/33271 A1	(HONEYWELL)-see abstract	
X	US 5099330	(CASIO)-see abstract, figure 3 and column 2 line 37 to column 3 line 10	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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